SWORD BEANS GROWN ON TERRACES TO PREVENT EROSION AND ENRICH THE SOIL.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1912.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., November 1, 1912.

SIR: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year ended June 30, 1912.

Respectfully,

D. W. MAY.
Special Agent in Charge.

Dr. A. C. TRUE,
Director, Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1912.

SUMMARY OF INVESTIGATIONS.

By D. W. May, *Special Agent in Charge.*

INTRODUCTION.

Porto Rico has had another prosperous year. Her exports, nearly all agricultural products, exceed those of the previous year by $10,000,000, amounting to $49,705,413, a sum larger than ever known before in the island's history.

While sugar still leads, the striking feature of production is new and diversified crops. The fruit industry, from a beginning dating only a few years ago, amounted to over $2,000,000. Coffee that had languished since the American occupation is gaining not only in price but in production.

With the great increase in production in Porto Rico, the trade of the island increasing fivefold since 1901, the possibilities have by no means reached a limit. There is not only much land yet not cultivated, but the intensive cultivation of the soil is only beginning and is to no extent as yet a matter of common practice.

While the insect and fungus troubles of plants in the Tropics are multiplied, the yields where these are successfully combated and good cultivation practiced are enormously increased over those obtained in more temperate zones. Less land but more intensive cultivation should be the practice in tropical agriculture. One great mistake usually made by planters from the North is the attempt to cultivate too much land. Where there is a growing season of 12 months it is easily apparent that it will cost more to cultivate than where frost puts the land out of cultivation and keeps it clean for 4 or 5 months of the year.

LINES OF WORK.

The station work has naturally drifted toward specialization, with basic principles in view. Tropical agriculture presents different characteristics from those in the Temperate Zone and this in turn is

caused by differences in soil as well as climate. Special attention, therefore, has been directed toward the study of the soil, its chemical composition, and the bacterial and animal life inhabiting it.

Tropical soils are often thought of as covered with dense vegetation. This is usually the case under natural conditions, but the most fertile may become sterile and unproductive by the improvident hand of man. Fertile land in the Tropics covered with a heavy growth of timber, when denuded becomes poor and unproductive, producing only scant grasses and brush. Besides the washing, the humus of these soils is soon destroyed by the scorching rays of the tropical sun, and the favorable bacteria under such conditions disappear or are greatly reduced in number.

One of the greatest problems in Porto Rico is that of bringing such lands again into profitable production. Fertilizers for this purpose are costly and the betterment caused by their application at best is only temporary. A more reasonable method appears to be by growing legumes on the land. Nitrogen in most cases is, after all, the limiting factor in agricultural production in Porto Rico. While it is the most expensive element in fertilizers, it is the one most easily available to our lands. From the immense stores in the air overlying the fields nitrogen can be drawn through the large number of legumes well suited to the soils and climate.

Cowpeas mature in 70 days and will grow in most sections throughout the year. The sword bean (*Canavalia* sp.) is very hardy and suitable under most adverse conditions (see frontispiece). *Dolichos lablab* grows wild and produces forage while storing nitrogen in the soil. The gandul or pigeon pea follows man around the tropical belt of the world and the humblest homes are surrounded by them, affording food while enriching the soil. Many trees, too, are available for reclaiming waste or unproductive land. The gallito (*Agati grandiflora*), of India is one of the best temporary trees for this purpose. It is a wonderful collector of nitrogen as are some native trees, such as the bucare (*Erythrina* sp.), guamá (*Inga laurina*), guava (*Inga vera*), and moca (*Andira inermis*).

It is the policy of the station to promote by every means possible the planting of legumes. By advice, by precept, by example, by the free distribution of seeds and plants, this has been urged. The lands of Porto Rico are becoming more and more valuable, and they should not remain idle and unproductive. The planting of a legume makes possible the production of a more valuable crop. The coffee industry has survived without rotation not because of the shade, to which it is ascribed, but because of the fact that without exception the shade trees are legumes and are continually putting into the soil the essential nitrogen needed by the recurring crops of coffee.

FIG. 1.—COLUMNARIS COFFEE TREES, THREE YEARS FROM SEED BED.

FIG. 2.—SOME TYPES OF COFFEE GROWN AT STATION, SHOWING BERRIES, COFFEE IN PARCHMENT, AND GRAIN.

Fruit growers, too, need to plant more legumes not alone for windbreaks but for nitrogen. It is not necessary for them to buy this element when needed amounts can be so easily secured through leguminous trees used for windbreaks and the beans and peas which are so well adapted to cover crops.

COFFEE.

There has been no recent extension in the planting of coffee. There is, however, pronounced improvement in the cultivation and resulting yield. Prices also are better, owing partly to the production of a better bean but especially to the increase in price of all coffees in the world's markets. There is not likely to be a greater area planted to coffee in Porto Rico. Owing to improved trade relations, rock roads and better shipping service, the island is rapidly falling within the area where perishable products may be quickly and cheaply placed in the best markets of the world—the areas of large population in the United States. Coffee being a compact, nonperishable product, lends itself readily to outlying lands and inaccessible areas of the Tropics. In Porto Rico there is a movement toward diversified agriculture in the mountain lands, and coffee, the former king, is giving way to fruits.

There is, however, considerable land in Porto Rico somewhat inaccessible that can be profitably devoted to coffee. The station is growing coffees from different countries of the world, some of which have been bred up to higher yields of excellent beans. (Plate I.) Seeds of these are distributed annually without cost and planters are urged to try them as well as to carry on a system of careful selection of their own trees for planting. Porto Rican coffee is well relished and sells for high prices in certain markets. That the yields are low is due in great measure to the fact that seed selection has not been practiced, but on the contrary groves are set of volunteer trees that have sprung up under the old trees from shattered coffee, in many cases from immature or diseased beans.

Instances are multiplying where old run-down coffee plantations have been put upon a paying basis by improved cultivation and diversification.

The fruit industry in Porto Rico has made a great gain during the year, exports amounting to over $2,000,000. Porto Rican fruits, although new in the mainland markets, have already won a high place. Grapefruit especially has already become noted, and sales in the open market have reached $12 per box.

In matters of production the fruit growers of to-day have a marked advantage over those of a few years ago, when this industry was in the pioneer stage. Problems have been solved that go a long way

toward eliminating the question of chance. Fruit soils and the proper location and protection of groves are better determined. While there will always be a large element of chance in fruit production, yet many of the mistakes in the beginning of the industry in the island may now be avoided. With continued perseverance and intelligence applied to the business, fruit growing is destined to become the premier industry of Porto Rico.

TOBACCO.

The tobacco lands of Porto Rico where the best qualities can be grown are somewhat limited in extent. While the acreage does not show a large increase from year to year, there is, on the other hand, a distinct betterment of the quality. The manufacturing of cigars and cigarettes has shown the greatest increase, and Porto Rican cigars may now be found in all sections of the United States, where a few years ago they were unknown.

The Porto Rican American Tobacco Co. has established an experiment station at Caguas, P. R., in the heart of the tobacco industry, which has materially helped in improving the yield and the quality of our tobaccos.

SUGAR CANE.

In annual production sugar cane still leads in value over all other crops. The area that can be profitably planted to this crop has been planted about up to the limit. All the coast lands have been planted and the cane extended into the hills until losses have occurred to stop the advance. Even the coast lands in some cases, because of repeated harvests, are becoming unprofitable. They do not always respond to fertilizers, and, having become infested with cane diseases, the only recourse left to the planter is to rotate them.

The cane growers have wisely established an experiment station to study the various questions relating to their industry. This station is therefore devoting less especial attention to this crop than formerly. Such experiments as are conducted are mainly along the line of rotations for this crop. Some work in cane breeding and the introduction of new varieties from other countries is being continued.

FARM ENGINEERING.

During the year many improvements have been made in the station property. These have been of a permanent nature. In the Tropics even the best of wood is very perishable. The damp nights followed by hot days soon cause rot, and, besides, certain insects, as the white ant, soon destroy wood protected from the elements. In all station work cement is used wherever possible.

The wooden culverts on the farm have been replaced with cement. Cement fence posts are replacing the wooden ones as rapidly as they can be made. A cement tunnel has been constructed from the cistern where the tile empty, direct to the river. This obviates the continual cleaning of a large surface ditch and carries off the water more quickly after heavy rains.

A machine for making cement tile has been purchased and the tile are now under trial compared with clay tile. Where the cost of wood for burning is as high as it is in Porto Rico, cement tile can be made at a less cost than clay tile.

Cement blocks, both hollow and solid, have been used during the year in constructing several small houses. Molds were made of 1-inch boards 6 by 8 by 18 inches and without top and bottom. These were fastened together at the corners with wooden pins so that they could be easily taken apart. In them was placed a mixture of cement, sand, and gravel in the proportions of 1:3:5. Into this mixture, while still soft, there were packed as close as they would go stones 2 to 4 inches in diameter, from the river. The next day the forms were taken off and the process repeated. In this way a very economical block was made and one which required a minimum amount of cement. Where stones can be had so cheaply from the near-by river, a solid block of this description costs less than a hollow one, where no stones could be used.

COOPERATIVE WORK.

The growing of fiber crops in cooperation with the insular government is being continued. Seventy-five acres of sisal are planted on government land on the south coast in the arid region. Fifteen acres of this is ready to cut, and during the coming year machinery will be installed for its extraction.

Two crops of sea-island cotton were grown on 50 acres of this land as an experiment. Owing to an unusually dry season the yield was small, barely paying expenses. The crop was sold for 27 cents per pound, f. o. b. Mayaguez.

The 200 acres of table-land above the city of Mayaguez set aside for experiments in reforesting has been partly planted to economic trees. Cabinet woods, nuts, and improved varieties of mango are being planted on this area.

AGRICULTURAL ORGANIZATIONS.

Besides the tobacco experiment station and the sugar growers' station before mentioned, the insular government has organized a bureau of agriculture that is materially assisting this station in

promoting better agriculture in Porto Rico. The organization of the agricultural college on land adjoining the experiment station will be of great value to the island, especially in getting results before the farmers and in educating the people along the line of their greatest endeavor.

There should be mentioned also the experimental work of the Guanica Centrale, the Fajardo Sugar Co., and of San Cristóbal Central, all of which have cooperated with this station in the introduction and breeding of sugar canes and the study of their fertilization and cultivation.

REPORT OF THE PHYSIOLOGIST.

By Oscar Loew.

PROTOZOAN LIFE IN SOILS OF PORTO RICO.

The occurrence and rôle of protozoa in soils have awakened much interest in recent years and various hypotheses have been founded on them.

In 1908 M. Wolff[1] studied the influence of irrigation on the protozoan fauna in soils and found 13 kinds of Sarcodina, 19 kinds of Flagellata, and 19 kinds of Ciliata. Many of these protozoa, like some algæ, develop only under the influence of irrigation or in soils continuously moist. Wolff himself does not assume the general occurrence in all kinds of soil of all the protozoan forms observed by him and points out that there are a number of leading forms which are encountered more frequently than others. Among these leading forms are:

Sarcodina: *Amœba terricola*, *Hyalodiscus guttula* and *H. limax*, *Arcella vulgaris*, *Difflugia constricta*, and *Gromia terricola*.

Flagellata: Two kinds of Monas, one of Pleuromonas, one of Chlamydomonas, and four kinds of Bodo.

Ciliata (Infusoria): *Nassula elegans*, *Glaucoma scintillans*, *Balantiophorus minutus*, *Colpidium colpoda*, and *Colpoda cucullus*.

Many questions as to soil protozoa are still unanswered. Do the same species occur in various kinds of soils, or are they different in sandy, clay, and humus soil? To what depth do they occur in different soils? Do acid soils contain all the species which occur in neutral soils? Does heavy liming or manuring with organic mixtures, as stable manure or cottonseed meal, have any influence on the constancy of the protozoan fauna? Do different forms predominate in tropical soils and soils of northern countries? All these questions have not only technical but also some practical interest since microbes, be they useful or injurious, form the chief food[2] for these protozoa which are reported to occur frequently in immense numbers in certain soils of the proper mechanical and chemical qualities. In 1 gram of garden soil Hiltner observed millions of protozoa, mostly amœba.

M. Wolff is of the opinion that the very voracious kind of Flagellata, Bodo, and Monas also can contribute to a purification of soils in regard to parasitic fungi, since these organisms can frequently be observed sucking out spores of such fungi in a germinating con-

[1] Centbl. Bakt. [etc.] 2. Abt., 33 (1912), No. 11–14, p. 314.

[2] It is asserted that *Amœba limax* also feeds on dissolved organic matter.

dition. Ungerminated fungus spores are generally not digested by protozoa.

Russell and Hutchinson pointed out that the number of microbes in the soil is limited by the great frequency of protozoa, and that if these protozoa are killed by means of disinfecting compounds, as bisulphid of carbon, the increase of microbes developed after a certain time brings on also an increase of ammonia from destroyed organic matter.

Stormer, in testing soils, observed development of amœbæ on neutral agar; he also observed that in soils treated with disinfectants the protozoa were dead.

The series of leading soil protozoa mentioned by Wolff does not, however, according to our observations, occur in all soils. Only a few are of general occurrence under adverse soil conditions. The infusorium most frequently found is *Colpoda cucullus*.

This kind may be considered as the most generally occurring soil infusorium. The writer found this form not only in moderately alkaline soils but even in very acid and stiff clay soils in which not a single other protozoan species could be detected. The same infusorium was found by the writer in the sand dunes of the island of Borkum, in the mountain soils of the Alps, and in the most different kinds of soil in Japan.

This infusorium, on account of its frequency, also awakened the interest of Hutchinson of the Rothamsted experiment station, who informed the writer that he had found it to be not only a general inhabitant of English soils but also of various tropical soils.

Not only is this organism adapted to the deficiently aerated stiff clay soils but also to the dry, coarse, sandy soils. The writer has observed it as the only kind of infusoria in loose sandy soils (from 10 inches depth) of the Porto Rican coast, when the test flask for Azotobacter remained standing for eight days at 24 to 33° C.

Amœbæ were encountered to a moderate extent in various soils, but not in the stiff and acid clay soil of the experiment station, though the infusorium *Colpoda cucullus* occurs in this soil to a depth of 3 inches. When *C. cucullus* is present in a culture with numerous small Flagellata it can be observed feeding upon them, and when overfed it assumes a resting position for digestion.

SOILS AND MINERAL NUTRIENTS.

Pure clay soils, called stiff or heavy clay, are especially frequent in Porto Rico and it is a surprising fact that in spite of very poor aeration many plants can develop well on them. This fact, however, can be explained by the formation of an extended system of surface roots which develop so near the surface of the clay soils that they can procure as much oxygen from the air as they need. Especially

may be mentioned the orange, pomarrosa, guava, guamá, bucare, and the banana.

There are greater differences between the soils in tropical and northern climates than one would suppose. In the first place there is the color. An intense red color of soils is very usual in tropical countries, while in northern countries the color is mostly brown, yellowish, gray, or black. This condition is partly due to a higher degree of chemical disintegration, whereby the ferric silicates are further split into the brown ferric hydrate and silica, and the former is further changed to red ferric oxid, and partly to the frequent absence of humus, which would impart a dark color to the originally red soil. In some tropical countries the changes by disintegration go much further and lead to the rather sterile laterite. The absence of humus forms a second characteristic of tropical soils. While in northern countries it is considered as one of the properties of lime in the soils to aid the transformation of organic matters into humus and finally also the oxidation of the humus whereby its nitrogen is rendered available to the roots, such a rôle of lime is not observed in the Tropics. The decomposition of organic matters in the soil is, under the influence of the continuously high temperature, much more energetic than in cooler climates, and therefore the little humus formed is rapidly oxidized again, even in quite acid soils and without the help of carbonate of lime. Only in swamps are large amounts of humus formed in the Tropics.

A third characteristic circumstance for tropical soils is the increased loss of lime caused by the rains at high temperature; in consequence of this there is an excess of magnesia over lime in the soils, a very frequent phenomenon in the Tropics, while in northern countries it forms the exception.

A further characteristic is the unusually frequent acidity of soils. More than 30 samples of soils, chiefly from the western part of the island and partly also from the region of Bayamon, Rio Piedras, and Caguas have been examined, and in all of them more or less acidity was found. Only the sandy soils from the coast and the limestone soils near the coral hills were found neutral. The acidity is not due to humic acid, as often is the case in soils of northern countries, but to an acid clay, and it is produced by the action of carbon dioxid and water at high temperature upon the neutral clay which has to be considered as a combination of the acid clay with various bases, as potash, soda, lime, magnesia, and ferrous oxid.

The degree of acidity can easily be determined by shaking a given quantity, say 50 grams, with a dilute solution of sodium acetate (200 cubic centimenters of a 1 per cent solution), and, after allowing to stand for 24 hours and shaking the mixture repeatedly, filtering the solution and determining the acetic acid set free from the acetate

by the acid clay. Thus it was found that for 1 kilogram there would be required from 0.1 to 1.5 grams sodium hydroxid for neutralization, according to the locality.

From this it may be easily calculated how much lime would be necessary for neutralizing an acre of such acid soil to the depth of 5 or 8 inches. In some cases the amount of lime would be so enormous that its application could not be called economical, although the improvement of the soil would soon show in higher yields. While it is, however, not absolutely necessary to lime in one operation to such an extent, an annual moderate liming should not be neglected, since the leaching out of lime by rain is very considerable. It is a noticeable fact that many plants, such as banana, coffee, and orange, have adapted themselves to acid soils in a remarkable manner. Of crops of northern countries, barley, wheat, clover, and alfalfa are examples of plants very sensitive to acidity in soils, while the potato and buckwheat thrive well on moderately acid soils.

A fact further deserving to be mentioned is that the minimum of mineral nutrients required for a satisfactory harvest is lower in the Tropics than in northern countries. In manuring acid soils superphosphate should be replaced by basic slag or bone meal, ammonium sulphate by tankage or well rotted stable manure. In short, acid manures should be avoided and replaced by alkaline manures.

There are three different nitrogen gatherers in the soils of Porto Rico among the microbes that live upon organic matters, which can furnish them the necessary carbon. The first is *Bacterium radicicola*, which enters the roots of leguminous plants and produces there the well-known nodules. The second microbe, which is very important but grows luxuriantly only in soils containing carbonate of lime and which never enters the roots of any plant but lives free in the soil, is Azotobacter, which occurs in several varieties and was found by the writer even in acid solids of Porto Rico. This bacterium grows chiefly near the soil surface and needs air for its life. The third bacterium is the butyric bacillus, which occurs in all kinds of soils, even in the stiffest clay and most acid and most alkaline soils. The writer found it in clay soils at 18 inches and once even to a depth of 30 inches. This bacillus can live without air and can multiply under the condition that some fermentable material, as sugar or starch, is furnished to it by decaying roots or organic manures. It produces a most energetic fermentation in a solution of glucose, whereby butyric and acetic acids and further carbonic acid and hydrogen gas is produced. This bacillus forms spores which can remain a long time alive in the soil and awake to activity as soon as from a decaying root some suitable organic matter reaches them. As a nitrogen gatherer, however, it can hardly be compared with the great activity of Azotobacter and *Bacterium radicicola*.

SUPPLEMENTING THE MINERAL NUTRIENTS IN THE TROPICS.

It is an old observation that most persons coming from northern countries to settle in tropical regions gradually decrease in body weight, due to the dwindling of the muscles. Also reduction of the number of red corpuscles has been observed, but the primary physiological causes of these phenomena have never been sufficiently elucidated.

A generalization for all tropical countries without exception would be unjustified, since the proximity of mountains to coast regions modifies considerably the effects of tropical heat. The western part of Porto Rico has such a favorable position. It is true the summer temperature rises almost daily to 89° F., but during the night there is a pleasant cool wave from the mountain regions near by, making possible a deep, sound sleep and banishing the beginnings of tropical neurasthenia which might develop in some sensitive persons. Even in July and August there is the cool night breeze, and the temperature sinks to 65° F. Besides, disease-breeding swamps are absent in Porto Rico. Indeed, many of the Americans who have lived in Porto Rico for years are still perfectly healthy, but some individuals encounter more difficulty in becoming acclimatized than do others.

Certain effects of tropical climates, however, are noticed also in Porto Rico; thus sometimes the tropical anemia occurs, especially with natives, and the tropical edema (swelling of the lower extremities), which develops sometimes with persons that emigrate to Porto Rico at a more advanced age.

In the opinion of the writer, the primary cause of the decrease of body weight is a weakening of the functions of all glandular organs in the gastro-intestinal tract, caused by drinking daily the large amounts of water a perspiring man is continuously forced to take. It would evidently be better to drink a physiological salt solution containing 0.6 to 0.8 per cent sodium chlorid instead of plain water. But another cause of weakening is the daily consumption of food too poor in lime and too rich in magnesia, as, for instance, rice. Since the writer, in conjunction with Prof. Emmerich, had observed with various persons increase of body weight by improvement of digestion after taking daily 1.5 grams of calcium chlorid, it was of interest to observe whether this supplementing of the mineral nutrition with calcium salt would also have such an effect in the Tropics. A series of experiments were made with a number of persons who were given 1.5 grams calcium chlorid per adult daily in the drinking water. The results were striking in most individuals, showing gains in weight and improvement in some cases where there had been indigestion and poor assimilation of the food.

REPORT OF THE CHEMIST.

By P. L. Gile.

INTRODUCTION.

Except for some analyses made for the other departments, the chemical work the past year has been directed to those problems in soils and plant nutrition outlined in the previous report. It is expected that two of the investigations started about three years ago will be completed the coming year.

While progress has been made in all the investigations, the efficiency of the work along some lines is still greatly affected by lack of equipment for conducting vegetative experiments in pots. Although a glass house is not essential for the proper conduct of such experiments here, protection from heavy rains, insects, birds, and rats is essential.

The equipment for soil and fertilizer studies has been increased during the year by the construction of 30 cement cylinders 3 feet in diameter, sunk in the ground to a depth of 3½ feet. At the present time certain vegetative experiments that can not be conducted in field plats are being carried on in these cylinders. This method of experimentation is satisfactory for the study of certain problems, but is not generally applicable to all work.

The necessity for additional equipment increases from year to year.

SUMMARY OF THE WORK.

During the year 160 samples, including soils, plant ashes, limestone, canes, waters, and certain miscellaneous materials, have been analyzed.

The work on the effect of strongly calcareous soils on the growth and composition of certain plants will probably be prepared for publication the coming year. It is expected that a preliminary report on the bat guanos of Porto Rico will also be prepared during that time. The investigations that are being continued are those on the action of lime in inducing chlorosis, the effects of various ratios

of lime to magnesia on the growth of plants, the treatment of the red clay soils, and the chlorosis of sugar cane. No new problems have been taken up the past year, but progress has been made on all the above problems.

In connection with the work on the chlorosis of sugar cane, field plats were established at Central Cortada last year for treating the cane with ferrous sulphate in various ways. These plats will not be cut until January, 1913, but at the present time marked differences are apparent in them, those sprayed with ferrous sulphate and those receiving the mixture of stable manure and ferrous sulphate appearing the best. A further field experiment of 5 acres on this subject is being started at Central Cortada. Thanks are due to the American Steel & Wire Co., which has kindly furnished 2,500 pounds of iron sulphate for this purpose.

The plats established last year to study the best treatment of the red clay soils will probably be cut in December of this year. From the appearance of the plats at the present time it does not appear that any of the treatments tried at Hormigueros are going to be very effective in increasing the yield of sugar cane on the unproductive soil. Differences, however, are apparent in the fertilizer plats established at Anasco on the more productive soil.

In the study of the action of lime in inducing chlorosis some interesting results have been secured with rice. The field plats at Central Cortada, mentioned above, also promise to give results bearing on this problem.

THE RED SANDY SOIL OF PUEBLO VIEJO AND BAYAMON.

Certain soil analyses made during the year that are not related directly to any of the above lines of work are given below as being of interest. The samples were taken from citrus groves in Pueblo Viejo and Bayamon, and, while they are by no means representative of all the soil in this district, they are of the red sandy soil, which is often found underlain by a rather stiff clay subsoil at a depth of several feet. This type of soil is a rather fine red sand, which is darker in color and more loamy in texture when it contains considerable organic matter and has a tendency to pack when lacking in it. The following samples are all of this type: Nos. 492 and 494 are surface soils of this type taken at Pueblo Viejo; samples 493 and 495 are the respective subsoils; Nos. 539 and 540 are the soil and subsoil from a grove in Bayamon; Nos. 541 and 542 are both surface samples from another grove in Bayamon, where pineapples are planted at present. The samples of surface soil represent the first foot of soil and the subsoil the second foot. The analyses of the soils

by digestion with hydrochloric acid of specific gravity, 1.115 are given in the following table:

Analysis of red sandy soils of Pueblo Viejo and Bayamon.

	Soil, Lab. No. 492.	Subsoil, Lab. No. 493.	Soil, Lab. No. 494.	Subsoil, Lab. No. 495.	Soil, Lab No. 539	Subsoil, Lab. No. 540.	Soil, Lab. No. 541.	Soil, Lab. No. 542.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble residue	90.14	78.20	86.66	77.40	85.29	79.40	77.84	77.31
Potash (K_2O)	0.04	0.08	0.02	0.06	0.01	0.08	0.07	0.01
Lime (CaO)	Trace.	Trace.	Trace.	Trace.	.26	.13	.33	.22
Magnesia (MgO)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	.12
Ferric oxid (Fe_2O_3)	2.02	3.99	2.94	4.79	5.72	7.86	9.65	9.73
Alumina (Al_2O_3)	4.12	12.71	5.67	10.66	2.88	6.68	1.33	1.69
Phosphorus pentoxid (P_2O_5)	.06	.04	.05	.06	.01	.01	.02	.02
Loss on ignition	3.89	5.79	5.23	6.92	5.25	6.10	10.44	11.11
Total	100.27	100.81	100.57	99.95	99.42	100.06	99.68	100.04
Nitrogen (N)	.06	.07	.07	.06	.12	.08	.22	.21
Carbon dioxid (CO_2)	.00	.00	.00	.00	.00	.00	.00	.00
Reaction to litmus	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

[1] Strongly acid.

In regard to the chemical character of these soils the following facts stand out plainly: The soils are strongly acid; they are particularly low in magnesia, potash, lime, and phosphoric acid; there is much more potash in the subsoil than in the surface soil; the nitrogen content of the two soils from Pueblo Viejo is low and that of the two soils from Bayamon is fair to good.

The subsoil is of slightly more clayey nature than the surface soil and is less weathered. The fact that there is more potash in the subsoil than the surface soil would point to this, although this might also be due to the potash being leached into the lower soil. The greater percentage of alumina and the greater loss on ignition in the subsoil than the surface soil also point to the second foot containing more clay of zeolite character.

While a chemical analysis is never a safe guide for fertilization, these particular analyses seem to substantiate results obtained by the horticulturist of the station in fertilizer experiments on soils 492 and 539, which show that this type of soil needs a complete fertilizer. The samples from Bayamon are particularly low in phosphoric acid.

That these soils would be much benefited by liming there is little doubt, since they are very deficient in lime and also strongly acid. While many citrus trees are making a good growth on acid soils, it is generally considered that the optimum condition for their growth is a neutral or slightly alkaline reaction. A chance application of lime was once made to soil 539, and the grower reported that following the application the trees receiving the lime put forth new growth, in strong contrast with unlimed trees. Liming is being tried on soil 492, but no results have been reported as yet.

The very small amount of magnesium in these soils makes it probable that a fertilizer containing magnesium would give good results. Rigaux found that Belgian soils containing 0.01 to 0.04 per cent MgO gave increased yields with a magnesian fertilizer.[1] The double manure salt of potassium and magnesium might thus give a better result than the high-grade sulphate of potash. If the land were limed with a limestone containing magnesium, however, enough magnesium would be supplied for the needs of the trees.

This type of soil is generally low in organic matter and is especially in need of it for holding the fertilizer applied and for improving the physical condition. The growth of leguminous cover crops on this type of soil has been strongly recommended. Sword beans grow well on this soil, and in spite of the acid condition develop enormous nodules. These nodules were examined by the pathologist and found to be true bacterial nodules, although nematode excrescences were also found on some roots. By keeping a leguminous cover crop in the citrus orchards on this type of soil the soil conditions would be much improved and considerably less nitrogen would be required in fertilizing the trees.

To secure the best results from citrus orchards on this type of soil heavy fertilization is required; lime and organic matter is also needed. It is recommended for citrus culture that these soils be limed every few years, that leguminous cover crops be grown, and that heavier fertilization be practiced here than on the richer soil types. Basic slag should serve well as a source of phosphoric acid because of the acid character of the soil, and for the same reason sodium nitrate or dried blood should serve better as sources of nitrogen than ammonium sulphate, which is physiologically acid.

ESTIMATION OF LIME IN PLANT ASHES.

In connection with the investigation on the effect of strongly calcareous soils on the ash composition of various plants, the acetate method for the determination of lime in plant ashes has been tested. This method for determining lime in the presence of iron, alumina, and phosphoric acid consists in precipitating the iron and aluminum as phosphates by ammonium acetate in slightly acid solution, and then precipitating the lime as oxalate in the presence of any phosphoric acid that has not been removed by the first precipitation.

The official method[2] for the determination of lime in plant ashes differs from the above in that a complete separation of the phosphoric acid is effected before the lime is precipitated by adding sufficient ferric chlorid to combine with all the phosphoric acid. Here, how-

[1] Bul. Assoc. Chim. Sucr., et Distill., 26 (1908), No. 6, p. 444.
[2] U. S. Dept. Agr., Bur. Chem. Bul. 107, rev., p. 22.

ever, a bulky precipitate of ferric phosphate results which has to be reprecipitated to free from lime.

The acetate method is much quicker, since the precipitate of ferric phosphate is so small that it is easy to handle and does not have to be reprecipitated. This method is given by Wiley [1] for the determination of lime in mineral phosphates, is used by König [2] for determining lime in plant ashes, and has lately been again suggested by Thompson and Morgan [3] for this purpose.

A comparison of the acetate and official method for the determination of lime in plant ashes was made by Mr. Ageton on seven samples of ash from cassava roots and stems. The results are given in the accompanying table:

Lime and magnesia in ash of cassava.

No. of sample.	Official method.		Acetate method.	
	CaO.	MgO.	CaO.	MgO.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
325	12.51	8.82	12.50	8.78
327	14.94	8.44	14.94	8.35
328	18.20	8.89	18.15	8.80
329	25.02	12.35	25.00	12.20
330	27.30	11.14	27.21	11.23
331	26.98	11.73	27.05	11.74
332	27.10	12.33	27.15	12.39

These results show that the acetate method is fully as accurate as the official method for the determination of lime and magnesia in plant ashes. Since these samples contained from 15 to 18 per cent of P_2O_5 and only 0.63 to 1.72 per cent of Fe_2O_3, it is evident that only a small portion of the phosphoric acid was removed before the precipitation of lime in the acetate method, and that the further addition of ferric chlorid, with its attendant difficulties, as prescribed by the official method, is unnecessary.

[1] Wiley, Principles and Practice of Agricultural Analysis. 1895, vol. 2, p. 24; 1908, 2. ed., vol. 2, p. 231.

[2] König, Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe. Berlin, 1906, 3. ed., rev., p. 201.

[3] Thompson and Morgan Jour. Indus. and Engin. Chem., 3 (1911), p. 398.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

CITRUS FRUITS.

Work with this crop has included the continuation of the cooperative fertilizer experiments, experiments with stocks, marketing problems, and orchard management (Pl. II, fig. 1).

An experiment was conducted to determine the practicability of packing for shipment the uncultivated oranges on the coffee plantations where they are grown instead of selling the ungraded fruit at small prices to shippers at seaports. The careless method now practiced in picking and delivering to market results in heavy losses both in the decaying of badly injured fruit before packing and in decay before it reaches the northern market. Heretofore the farmer has been paid from 30 to 60 cents per box for an excellent product after he has delivered it to a coast town, and the heavy decay often results disastrously with those who buy for shipment. The marketing work carried on during the past year was largely confined to one coffee plantation 2 miles from the coast. This is a typical small coffee plantation, being hilly and wooded and having the orange trees, which grow wild, scattered through it. The crop was much below normal, there being only 90 boxes of packed fruit and 3 of culls harvested. As is the rule, this wild fruit, which grows among the larger coffee shade trees, is well protected from the wind and is bright and clean, being free from insects and russet. The culled fruit was that which had been scarred by insects or diseases while the fruit was young, or fruit with "creased" or ruptured inner skins. The laborers employed for tending the coffee have less work with it during the orange-picking season than during other parts of the year and they were able to do all the work with the fruit except that instruction was necessary for the packing. The equipment necessary for handling the crop was largely homemade and inexpensive. As this was the first experience the laborers had had of this nature, the work progressed slowly, but the grade of their work improved rapidly. The crop was marketed in three lots. From the first lot 17 per cent decay was reported, and from the other two all fruit was reported as being sound. The average price received per box for the entire crop was $1.75, which compared well with many sales of cultivated fruit and was much in advance of that paid for wild fruit, which was marketed in the customary way. Half of the

oranges for the last shipment were allowed to cure in open bins for three days before packing, while the other half were picked and boxed immediately before shipping. No decay from either lot was reported by the salesmen. The experience from the trial indicates that this excellent uncultivated fruit can be cheaply harvested and marketed by the laborers on the plantations with but little loss of fruit by decay and that the profits will be much in excess of that received by following the old method, as the shipped boxes bring satisfactory prices and the amount discarded before shipping is materially decreased by careful work.

In this locality where the oranges ripen during the dry season the skin is dry and tough if the fruit is left on the tree until from January to March and but little, if any, curing is necessary before shipment. In a demonstration to show the results of skin injuries, three boxes of sound and three of skin-punctured fruits were packed and stored 11 days. When opened 3 per cent from the sound boxes had decayed and 34 per cent of the punctured fruits.

The cooperative fertilizer experiments have been practically closed and the data are being arranged for publication. In the two groves where the work has been under way the fruit from each crop was counted and weighed and the influence of the different treatments found to be more pronounced than last year. The plats receiving a complete fertilizer yielded much better, in some cases 100 per cent more, than those receiving an incomplete fertilizer, and all fertilized plats produced much more than the check rows. These results would be expected, as a chemical analysis of the soil shows that it is exceedingly low in fertility, but little more than traces being found of potash and phosphates. The product from the plat receiving potash and nitrogen was much less than that from any other plate receiving an incomplete fertilizer. But small differences have been observed between the use of muriate and sulphate of potash, and the plats to test the merits of these elements are being continued.

Work with the various types of citrus stocks has been continued, and wide differences in thriftiness of seedling types have been noted. The test is on a slightly sloping site, where sour-orange, sweet-orange, rough-lemon, and grapefruit seedlings were set in a heavy clay which does not drain well. The growth of all was unsatisfactory during the months of excessive rains, but during the drier months the lemon seedlings grew well, the sour orange was somewhat less thrifty, while the sweet orange and grapefruit, which were about equal, made a slow and unsatisfactory growth. Plantings of the different types have been made in a more favorable soil for testing under orchard conditions.

A variety orchard which was set several years ago has proven so unsatisfactory that it has been removed during the past year. The

FIG. 1.—GUAMA, IGNA LAURINA, AS A WINDBREAK.

FIG. 2.—VARIETY TEST OF YAMS.

FIG. 1.—MULGOA MANGO.

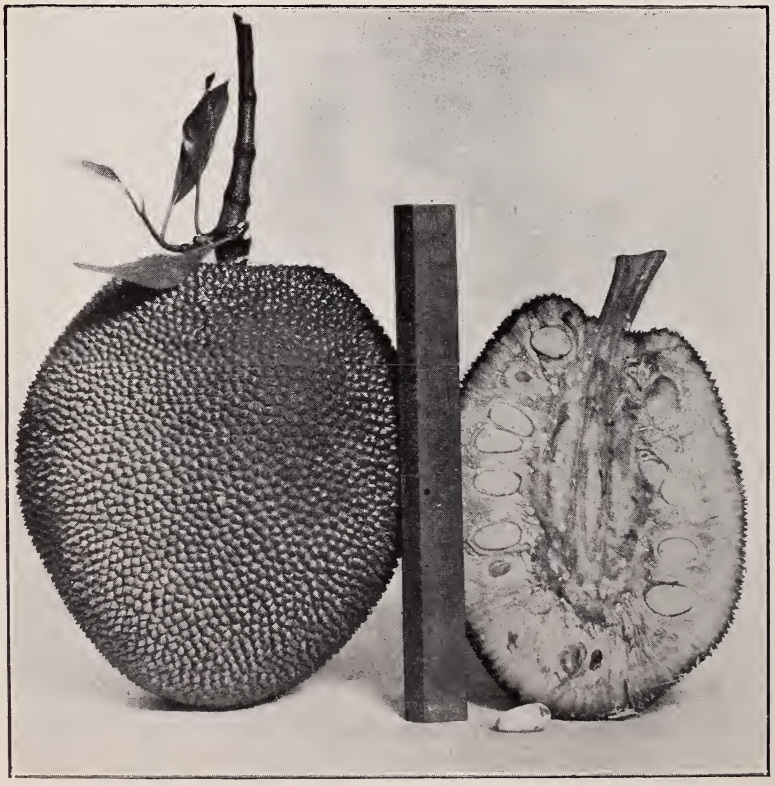

FIG. 2.—JACK FRUIT.

SOME PROMISING FRUITS INTRODUCED BY THE STATION.

location of this orchard was on an elevated area, where the soil is a heavy clay which drains poorly. During the time of drought, which continues through most of the winter, the roots are forced downward, where they can not thrive during the wet summer, when the water table is very near the soil surface. Hart late oranges and Duncan and Marsh seedless grapefruit withstood the conditions best.

MANGOES.

A number of varieties have been imported this year and set in the testing orchard. Sixty-four foreign types are now being cultivated at the station, the larger part of these being East Indian varieties. Plantings have been made to test commercially a number of varieties, which, from single trees now a few years old, indicate that they will succeed and prove to be profitable. Both native and imported types seem well suited to the conditions here, thriving on a variety of soils where other crops are not profitable and on land which is at present unproductive.

A number of varieties fruited this year and the crop on the fruiting trees was light, except with the varieties Sandersha, Mulgoba, Ameeri, and Cambodiana. A number of varieties have never borne, though the trees are from 4 to 6 years old and very thrifty. The varieties which fruited were Sandersha, Mulgoba, Mulgoa (Pl. III, fig. 1), Sufida, Bulbulchasm, Ameeri, Divine, Cambodiana, Totafari, Amini, D. B. Alphonse, all of which possess the favored qualities of the eastern mango and are far superior to our native types. A number of these imported trees, though never having been pruned, are very symmetrical and promise to be of value for ornamental use where a tree of dense, heavy foliage is desired.

As the value of different varieties is demonstrated, the choice kinds are being propagated for distribution at a nominal price to planters. In connection with the production of these trees, different methods of propagation, including budding, inarching, and grafting, are being tested. The grafting of potted or nursery seedlings has been successful this season.

COCONUTS.

In cooperation with Guanica Centrale, a coconut fertilizer experiment has been started in a grove situated near the coast between Mayaguez and Anasco. The conditions in this location are almost ideal, the soil being a light sandy loam. The field is but a few feet above the sea and lies almost level, and the trees are old and at present produce but small crops. For the work with fertilizers, 7 plats have been set aside, each containing 50 trees. Experiments with cover crops, cultivation, nursery problems, and the variation in productiveness of individual trees, will be carried on in connection with the fertilizer experiments.

Until within recent years but little cultivation was given to the coconut groves in Porto Rico, but as the nuts have greatly increased in popularity in the markets during the past year, now selling as a first-grade product, excellent profits are being realized from productive groves and attention is being given to fertilization, cultivation, drainage, etc., with good results.

ROOT CROPS.

Work with root crops, including sweet potatoes, yautias, dasheens, yams, and arrowroot, is being continued. Each of the 20 varieties of sweet potatoes grown during the last year produced a fair crop, but field rats were so troublesome that it was impossible to get an accurate record of the production. At the beginning of the long winter drought another planting was made, but the resulting crop was too light to be profitable. During the present season plantings of all varieties have been made at the station and also on a sandy soil near the beach north of Dorado.

The effect of commercial fertilizers on the yield of yams (Pl. II, fig. 2) was not decisive on the last crop, though interesting data have been taken from the work and the experiment is being continued. The influence of distance and size of tubers planted, which was tested with the variety Potato, has been very marked on the yield. Where hills were planted 2 by 2 feet on level land the average production per hill was 2.46 pounds, and where planted 4 by 4 feet the average production per hill was 5.11 pounds. Calculated per acre, the closer planting gave over 13 tons of tubers, while the yield from the wider planting was but little over half as much. In the ridge plantings the hills which were separated 20 inches gave 5.07 pounds of tubers per hill, while when planted 10 inches apart the yield was 3.93 pounds per hill. Where medium sized tubers were planted the average weight per hill was 5 pounds, and where small tubers were planted 4 pounds per hill. This variety should be very profitable in this locality, as the yield is heavy and the starch content of the tubers is $23\frac{1}{2}$ per cent.

With the large number of varieties of yautias and dasheens cultural, fertilizer, and variety tests are being continued. This crop seems to be well adapted to our conditions and all varieties made a splendid growth.

EUCALYPTUS.

During the past year 20 varieties of eucalyptus have been planted on high sloping land to compare with the same varieties which have been growing on low land for a number of years. Each variety started well and with the exception of a few varieties all are making a satisfactory growth. The kinds making the most vigorous growth

on the high land are *E. robusta*, *E. tereticornis*, *E. rostrata*, and *E. paniculata*. On the lower poorly drained soil *E. robusta*, *E. piperita*, and *E. tereticornis* are the only promising ones, though many trees of other varieties are living and making some growth. While the seedlings which were set during the past year were small, crown galls developed at or near the crown of a number of the varieties, in some cases increasing the diameter of the stem at that point to twice its normal size, but up to this time no apparent damage has resulted, the most thrifty trees often having the largest galls.

VEGETABLES.

Studying the influence of Porto Rican conditions on vegetables from seed imported from the north has been continued with interesting results. The second generation Early Valentine beans grown here were much inferior, both in vigor of the plants and in production, to the crop grown from the imported seed, but during successive generations there has been a gain in productiveness of the former, until the eighth generation has exceeded the yield from the first generation. Duplicate plantings from the original seed, from the second, and from the eighth generation were made in Porto Rico and in Minnesota during the summer and the harvest results ranked the same with different generations. The behavior of White Velvet okra has been in some ways the opposite of the beans, as with this crop the second generation has in different plantings resulted in the most vigorous plants and heaviest yield, the successive generations gradually degenerating. With other crops under observation the results are not pronounced.

The influence of subirrigation and surface irrigation was tested for garden practice by watering one area by surface ditches and the other with cement tubes. The tubes were 4 inches in diameter and 12 inches long and were laid at the entrance gate 8 inches deep and falling about an inch in 75 feet. A number of varieties of tomatoes, peppers, beans, onions, and eggplants were grown, each of which produced better and were much less expensive to cultivate in the subirrigated area. Crops growing above the tubes fruited much more heavily during the wet season than on the other land adjoining, as the tubes seemed to assist in draining or in aerating the heavy, wet soils.

Comparing a number of types of peppers which are common in the Porto Rican gardens with the most popular northern-grown varieties demonstrated that at least during the season of heavy rains the Porto Rican peppers were much more vigorous than the imported varieties and produced much heavier crops, while the texture and flavor of the pods from imported varieties was not superior to the native kinds.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The high coffee prices now prevailing have meant prosperous times for the Porto Rican coffee growers. More than 40,000,000 pounds were exported in the past fiscal year, having a valuation of 16.8 cents per pound. This stands in strong contrast to the valuation in 1903 of 11.2 cents per pound. It means that the coffee grower's net profits are now just twice what they were then. The exports to the States, though small, have increased considerably.

Frequently requests for information on coffee planting are received. To cover some of the points in question a circular[1] embodying suggestions along this line has been prepared for distribution.

The lines of investigation with coffee formerly undertaken are being continued, and, as many of the young trees are now producing, very interesting and valuable data as to yield are being accumulated. Notes are being taken also as to height and rate of growth of plats of trees which have received different fertilizer combinations or different cultural methods.

Though differences can be seen in the coffees which are due to differences in fertilizers or methods followed, in some cases these seem very small after two years' treatment, in comparison to the differences caused by the position of the tree; that is, generally speaking, whether it is found on the upper or lower part of a slope. On many slopes in the station plantings the trees below are in fine condition and those above poor. In such cases cultivation and the application of complete fertilizers have so far failed to overcome these unfavorable conditions, but in some instances have ameliorated them.

With such crops as coffee from slow-growing plants, which continue producing for many years, definite conclusions can be drawn only after a large amount of data is at hand.

Among the plantings of foreign coffee (*Coffee arabica*) the Padang is unusually fine, some of the trees being more than 11 feet high at a little over three years from seed. Though there are great variations in the trees of Erecta, some are exceedingly handsome and producing well. The Columnaris trees have made excellent growth and are fine

[1] Porto Rico Sta. Circ. 15.

specimens of coffee trees (Pl. I, fig. 1). Though they are of sufficient age to be producing heavily they are giving only a minimum yield.

There are in nursery beds at present fine young plants of *C. liberica* and *C. dewevrei* in sufficient numbers to make plantings which should be valuable as tests of these species under our conditions.

The experiment of felling the coffee shade on a part of the college farm to rid the coffee of the destructive ant (*Myrmelachista ambigua ramulorum*) has been highly successful. At the very edge of the felled plat a large Ceiba tree was left standing. This tree still harbors these ants and some are to be seen in small branches which have fallen from it and also in some of the coffee trees under its spread. Otherwise the ants in this plat have been practically exterminated, a long search revealing only rare instances in which a few ants of this species are to be seen in the coffee trees or guamá renews. On the whole, the coffee looks in a somewhat poor condition.

The coffee seed tests begun last year were repeated, with the result, as on previous tests, that seed that had been severely dried showed a rapid loss of viability. From those kept over concentrated sulphuric acid on the first test, which was at the end of two months, no seed germinated, while of two checks, one kept in the open air and the other over water in a closed jar, each gave a 95 per cent germination.

During the fall, seed of a number of imported coffees were distributed to coffee growers over the island.

VANILLA.

In the vanillery 12 plants blossomed this year, including *V. planifolia*, *V. pompona*, *V. eggersii*, *V. phantha*, and vanillas of undetermined species. In the spring some very dry weather caused many fruits that had set to drop, some vines losing all pods. It was gratifying to note, however, that no pods of *V. planifolia* were so lost. Cuttings of this species have become available, so that there are at present some 20 plants of *V. planifolia* at the station. Why the cultivation of this crop has never been undertaken commercially in the island is unknown, since very fine vanilla has been grown here as a curiosity in private gardens. The prospects for its successful culture seem very good.

Some cuttings have been distributed, but it was thought best to distribute these sparingly, as the vines are needed for a thorough test at the station.

RUBBER.

Of the plantings of 200 trees of *Castilla* sp. made in 1903 less than 100 have survived to date. The land in which they are planted slopes down to a small stream. On the lower land near the stream

the trees have grown well, but a little back from it and up the slope the greater part of those that have not died have made very poor growth. Measurements in April showed for the whole an average girth of 18 inches at 3 feet above the base. Only 31 trees were of sufficient girth to permit tapping. The yields of rubber have been small.

New plantings have been made of *Castilla panamensis*, *C. lactiflua*, and *Castilla* sp. from Mexico.

Seed of *Castilla* sp. have not been distributed, as more and varied plantings are necessary before any results can be hoped for. Complaints of seed not germinating are frequently heard. It was found that the viability could be prolonged considerably by keeping the seed between layers of fine soil and charcoal, mixed and slightly dampened. Two lots of seed were simultaneously picked, pulped, and washed. One lot was spread out in a thin layer in the open air, the other packed in mixed soil and charcoal. Seed from the former germinated well for less than two weeks, and in a little more than five weeks quit germinating altogether, while those from the latter still showed a 93 per cent germination. After this, however, the percentage germinating fell rapidly.

CACAO.

The yields of cacao have been recorded and show an increase over those of the year preceding. The average of six pods per tree is very small for trees 8 years old. Cacao, S. P. I. 11656, planted out nearly eight years is now just beginning to produce. (Pl. IV, fig. 1.) The pods are not large, but the seed is of average size and in section is pure white, indicating superior quality.

MISCELLANEOUS.

The station has been very active in introducing new fruits into Porto Rico, some of which have fruited and promise to prove valuable acquisitions. (Pls. III and V.)

REPORT OF THE PLANT PATHOLOGIST.

By G. L. Fawcett.

BANANA DISEASES.

The effect of the use of "seed" free from disease and of the ordinary unselected seed is being tried, and also the effect of cultivation and fertilizer in keeping down the common disease of this plant. No organism has been found here which inoculation has shown to be clearly parasitic when introduced in pure culture. It seems probable that unfavorable soil conditions may weaken the plant and render it susceptible to some slightly parasitic bacteria and fungi which it ordinarily is able to resist. Such soil conditions include excess of water in the soil and continued growth for a number of years among the old decaying stumps left after the removal of the fruit. The inability of the Fusarium commonly occurring in the diseased tissue to act parasitically even when introduced in considerable quantities into healthy plants has been demonstrated repeatedly in this work, although a slight parasitism of this fungus in older or weakened plants has been observed.

CITRUS-FRUIT DISEASES.

The anthracnose of grapefruit was somewhat troublesome this year, perhaps favored by unusually heavy rains. It was found that the mere presence of the spores of the anthracnose fungus did not mean that the spots would be produced on the fruits. Fruits covered with the spores remained healthy unless punctured slightly with a needle, in which case they developed the spots at the point of injury. It would seem from this that the wounds made by scales or other insects must greatly favor this spot of the fruit.

COFFEE DISEASES.

The work with the West Indian coffee diseases has been confined to the search for another form of *Stilbella flavida* on some of the shade trees, especially the guava, *Inga vera*, which is used extensively where the disease is most destructive. The disease seems to be most abundant under this tree in some plantations with mixed shade. Inoculations into coffee leaves with various fungi suspected of representing such a form of Stilbella have been made, but with-

out positive results. There are certain problems in the distribution of this disease which would be more readily explained through the existence of such an intermediary host. As the guava is a valued shade tree, experiments as to the effect of its removal on the disease are hardly to be recommended, in the absence of proof of any bad effect from their growing in coffee plantations.

A root disease has been found of a different type with respect to the causal organism from the common form. In its action it is essentially the same as the usual root disease, though perhaps more parasitic, attacking and destroying young plants which the other often leaves unharmed. The fact also that it destroys certain quick-growing herbaceous plants which may be used in the experiments has made the study of the effect of soil treatment easier by giving quicker results. A long time, often several months, is necessary for the disease to destroy large coffee trees which have been used in this work hitherto. It is planned to publish separately an account of the work done with coffee diseases.

COCONUT DISEASES.

In some work with the diseases of the coconut palm an interesting point was observed in connection with the "cut" leaves, quite common on these trees, which are generally thought to be injured by the attacks of one of the common coconut beetles. It was found that the injury, at least in the groves near Dorado, was due to *Thielaviopsis ethaceticus*, the common pineapple fungus of cane. This fungus was found to penetrate the still unfolded young leaves and produce a discolored softened spot, often extending entirely through the leaf, a distance of 2 or 3 centimeters. Soon after the growth has carried the tightly folded leaflets up so far that expansion is possible they are broken off by the wind at the point of attack, and the gnawed appearance is given the leaf.

T. ethaceticus, together with a yeast, was invariably isolated from the affected tissues. Inoculations with the fungus into the unfolded leaves of trees at Mayaguez have given the characteristic cut appearance to the leaves. No infection resulted from inoculations with the accompanying yeast. There can be no doubt that, owing to the compact arrangement of the leaflets, any organism capable of producing decay in their tissues could produce the same appearance, and it is possible such exist. In the case under consideration, however, the pineapple fungus caused the injury. Petch [1] has reported it as causing bleeding and in some cases a decay of the trunks of these trees, and it has been isolated here previously from the tissue below the leaf bases of slow-growing trees. It is probable that the same fungus may sometimes cause bud rot. The trees with "cut" leaves were

[1] Circs. and Agr. Jour. Roy. Bot. Gard. Ceylon, 4 (1909), No. 22.

FIG. 1.—FIRST CROP OF GUADELOUPE CACAO.

FIG. 2.—TYPES OF NATIVE MARES.

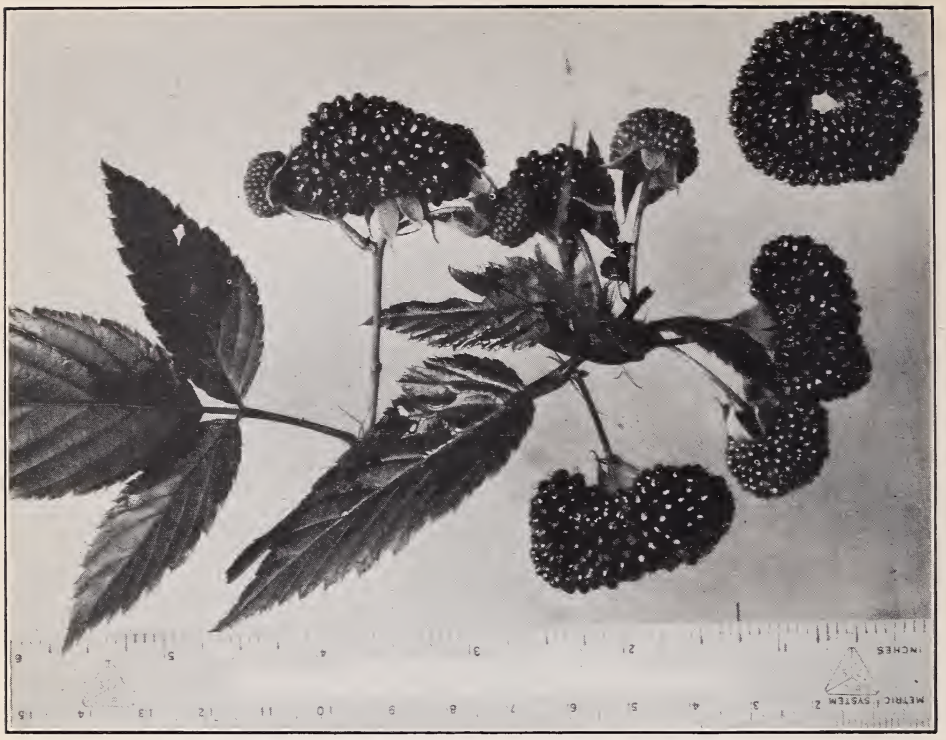

FIG. 1.—RUBUS HYBRID INTRODUCED FROM QUEENSLAND.

FIG. 2.—KAI APPLE, ABERIA CAFFRA.

SOME PROMISING FRUITS INTRODUCED BY THE STATION.

said by the owners of the grove to invariably succumb to bud rot after awhile. But it seems less probable that a tree in ordinarily favorable conditions would be injured, for the reason that the growth of the tree itself, with the consequent outward movement from the soft, easily injured tissues of the bud is a great safeguard against rot-producing organisms. The inoculations into the bundle of leaves were carried upward at the rate of 2 to 3 centimeters a day. The more rapidly growing tree also casts off more of the old fungus-harboring leaves. The groves where the disease occur are on very poor soil and have received no fertilizer. The yield of nuts is small and of poor quality. It is planned, with the cooperation of the owners, to try the effect of fertilizer on the unhealthy trees. Many of the apparently diseased trees have been felled and the affected parts burnt, but such sanitary measures promise little benefit if the fungus has already obtained a foothold in most of the other trees, as seems probable. It seems impossible to remove the diseased parts without destroying the tree.

REPORT OF THE ENTOMOLOGIST.

By C. W. Hooker.

The previous station entomologist, Mr. W. V. Tower, resigned July 1, 1911, and from then until November 2, 1911, the only work along this line was with bees. Few notes were available and very few insects in the collection were determined, hence progress has been slow. During the past year a system of note filing has been introduced, so that any information gathered on the various insects may be readily found. A large number of insects have been collected and preserved and several hundred have been sent to the United States National Museum for determination, duplicates being retained in the station collection for consultation.

During the past year the May beetles, changa, sugar-cane borers, and ants have as usual been most troublesome and their control most difficult. There have been local outbreaks of the cabbage worm, *Pontia monuste;* bean leaf-roller, *Eudamus proteus;* bean leaf-beetle, *Cerotoma trifurcata;* corn-ear worm, *Laphygma frugiperda*, and cucumber beetle, *Diabrotica vittata*, and on the south side of the island the green *Diabrotica graminea* has been very abundant, but has confined its attention mostly to weeds. Adults of a round-headed beetle, probably *Bostrychus monachus*, have evidently been boring at certain seasons for some time past in the station grapefruit trees, for many old healed-over wounds were found. This beetle was also taken boring in pigeon pea and gallito, *Agati grandiflora*, and is reported in flamboyant, coffee, and citron from other parts of the island. Five to 10 burrows were found in grapefruit and 20 burrows were found in a single stalk of pigeon pea, but no eggs, larvæ, or pupæ could be discovered, hence the principal host is as yet unknown.

The principal work of the past fiscal year has dealt with insect pests of coffee, mango, citrus fruits, and sugar cane, and with beneficial insects and fungi.

COFFEE.

The most troublesome coffee pest is an ant (*Myrmelachista ambigua ramulorum*), a species originally described from Culebra, Arecibo, and Utuado, P. R., where "it was nesting in rather populous colonies in hollow twigs of trees, especially the sea grape (*Coccoloba uvifera*) and 'torchuelo' (*Bicuda buceros*)." Its habits in the coffee-growing

region are similar. Here it lives mostly in the twigs and under pieces of loose bark on the trunk of the guamá, a hitherto popular coffee shade tree, and in dead wood on the coffee. It feeds largely on honeydew from two coccids, one a mealy bug, *Pseudococcus citri*, the other a large, fleshy, pink scale of the subfamily Coccinæ, probably as yet undescribed. These coccids are carried by the ants into canals eaten out along the pith of the smaller new growth which will bear the next season's fruit. This growth is thus weakened to such an extent that when bent down by the pickers at the next harvest it breaks easily. In this way much fruit is lost. The pickers are considerably annoyed by the ants.

Considerable work has been done with tanglefoot, repellents, and poisons, but nothing satisfactory has yet been found. It appears that a native ant, called "albayalde," when present naturally or when introduced, drives the coffee ants away, killing many and occupying their nests. These ants might possibly be used as an aid in fighting the coffee ants, but the pickers consider them far worse than the coffee pests, for their sting is quite painful.

The coffee leaf-miner (*Leucoptera coffeella*) is abundant throughout the island, and though its two chalcid parasites are everywhere present they seem to be numerous enough to check this pest only locally, and no effective method of treatment has been found.

A lepidopterous borer, determined by Dr. H. G. Dyar as *Psychonotua* sp., which was reported by Tower in 1908[1] as boring in orange, citron, rose apple, and sweet almond, has done considerable damage in certain sections, where the trunks and larger branches of the coffee plants are riddled with canals. When the damage is slight the larvæ may be killed by running a wire up the canals; later, when the canals are longer and shrubs are so riddled as in some places, the only safe method is to cut down and burn the trees and allow new growth to come up.

The coffee weevils are confined to certain hill districts, where they cause considerable injury. The eggs are laid between leaves, the larvæ descend and feed on the roots, and the adults feed on the leaves at the time when the plant is fruiting, thereby weakening it when strength is most needed.

The larvæ of one of the May beetles, or "caculos," is commonly found at the roots of coffee in the hill districts, and the adults feed on its leaves. In the western end of the island, at least, the adults are parasitized by a tachinid (*Cryptomeigenia* sp.), which in some cases is apparently an effective check. Work is now under way to learn if it is practical or advisable to propagate and distribute these parasites to coffee and sugar-cane plantations where the May beetles are troublesome.

[1] Porto Rico Sta. Rpt. 1908, p. 27.

FRUIT FLIES.

A fruit fly (*Anastrepha* sp.),[1] closely related to *A. acidusa*, breeds so commonly in one of the native mangoes (mangó de puerco) that it is difficult to get a good fruit from some trees. It also attacks some of the introduced Indian species, as the Cambodiana, 2 to 15 larvæ being found in a single fruit. It breeds freely in guava, jobo amarillo, and jobo de la India fruit as well, and as fruit is present on some of these trees the year round it is possible that this fly may breed throughout the year.

The lechosa fruit fly (*Toxotrypana curvicauda*) is abundant at Mayaguez and has been reported from St. Johns, Antigua, West Indies; Brazil, Peru, and Yucatan. The adult is a large bright yellow fly with black markings, yellowish transparent wings, and a long—14 millimeters—curved ovipositor. The eggs are laid well below the surface of the green fruit; 2 to 15 or more larvæ mature within the fruit, and when it drops pupate 1 or 2 inches below the surface of the ground immediately below the fruit. Adults emerge in 17 to 21 days, and eggs for another brood are soon laid.

Spraying with sweetened arsenate of lead and daily destroying the drops should soon control the lechosa fruit fly, though the adults are strong fliers. There is, however, little hope of checking the mango fruit fly, for its hosts grow wild in most parts of the island, and its parasites apparently attack it only in the jobo fruit. The larvæ in jobo are commonly attacked by two hymenopterous parasites, *Opius* (*Utetes*) *anastrephæ* n. sp., and *Ganaspis* n. sp.[2]

MAY BEETLES, OR CACULOS.

Some work has been done with the common May beetles, or caculos, whose larvæ attack the roots of sugar cane, coffee, citrus trees, pineapple, and aguacate. The adults, emerging from the ground at the base of the tree at night, feed on the newer leaves, frequently causing considerable injury. Various experiments with insecticides are now under way. The Japanese beetle fungus (*Metarrhizium anisoplioe*), which was introduced by this station some time ago from Hawaii, has been propagated and distributed with directions for use, the following method of growing on yam or sweet potato being recommended. It has been recovered from sections at some distance from where it is known to have been distributed, and is apparently spreading as

[1] This was first determined by W. R. Walton as *A. acidusa,* but comparison by Dr. L. O. Howard with the type of this species in the British Museum shows that the mango fruit fly is a different species, possibly undescribed. However, "Mr. Knab is now inclined to think that the species is *A. fraterculus,*" which has been recorded from Brazil, Peru, Colombia, Yucatan (Mexico), Cuba, and Porto Rico.

[2] The species of Opius was described by H. L. Viereck, of the United States Depatment of Agriculture, Bureau of Entomology, and the Ganaspis was determined by J. C. Crawford, of the United States National Museum, Division of Insects.

rapidly as could be expected, but just how effective it is can not be determined for some time.

DIRECTIONS FOR PROPAGATION OF THE CANE BEETLE FUNGUS BY THE PLANTERS.

Take a medium-sized yam or sweet potato (¼ to ½ pound), wash carefully, pare, and cut into sections 1 inch long by one-half inch thick. Cover these with water and boil for 20 minutes in a covered dish, then turn off all the water and set to one side to cool, being careful to replace the cover that no other fungi may enter. As soon as this media is partly cooled, yet somewhat warm, remove the squares of beetle fungus from the tubes and rub them over the upper surfaces of the squares of yam, being careful that the spores are evenly distributed. Place the squares with the newly sown fungus in several large-mouthed glass jars or bottles which have been properly sterilized with hot water and cover with a piece of glass, also dipped in hot water, or if not available a cloth wrung out in boiling water. The cover should be tight to keep out any other fungi or small flies which would otherwise breed in the media. By the second day a white growth should appear over the surface of the squares, and by the fourth or fifth day this should begin to turn to a greenish color due to the presence of spores. The time required for sporing varies considerably, but one or two weeks is usually sufficient. The jars should be kept away from the direct sunlight and good results have been obtained by keeping them in the dark a part of the time. As soon as the fungus has become a dark green color it is ready to use. Place several inches of earth in a box with a tight covering of wire or cloth, plant two or three pieces of cane with tender leaves for the beetles to eat, and mix several squares of the fungus in the earth. Collect a number of the cane beetles and, after rubbing some of the fungus over their bodies, place them in the cage for several days. The earth should be kept moist but not muddy, as the fungus will not work under these conditions. By examining the material in the box every few days you will soon find that a number of the beetles have died and that their bodies are covered with the fungus. The remaining live beetles should now be freed in the field to carry the disease through the cane fields or citrus orchards, while the dead ones and other squares of beetle fungus should be scattered through the fields mixed with earth at the base of the cane or trees. A cage once infested will remain effective for months and may be used for many lots of beetles, but the cane may need to be replaced to keep the leaves fresh.

BENEFICIAL INSECTS.

A colony of ladybirds (*Cryptolæmus montrouzieri*) was secured from the Sugar Growers' Experiment Station at Rio Piedras, and as these increased several hundred have been distributed to sugar and pineapple growers, in whose fields they should be effective aids in controlling the mealy bug (*Pseudococcus citri*).

A colony of aphis-feeding ladybirds (*Hippodamia convergens*) was introduced from California and freed at various points in Mayaguez, where aphids were abundant. As the aphids are usually held in check by the rains, syrphid flies, hymenopterous parasites, and three native ladybirds, this new introduction is not a necessity, but may prove useful, as it breeds rapidly.

BEES.

Beekeeping is now an industry of considerable importance in Porto Rico, and efforts have been made to encourage its growth. Experiments made with cement for hives and stands promise good results, but it is a new field, and just how far it can be used needs to be determined. In Porto Rico the stands, bases, and brood chamber often decay in a short time. These three parts can be made of cement at an equal or less cost than the wooden ones now in use, and not only last longer, but keep the brood chamber several degrees cooler.

A bee census of the island is now under way, and with this fuller information as to conditions the station should be better able to help the bee growers. For the past year the weight of two hives has been taken regularly night and morning to determine the amount of honey stored by a single swarm. One 10-frame hive with 4 supers made 357 pounds; a second, with 2 supers, made 539 pounds. The largest amount stored in one day by a single hive was 12 pounds. The average for one swarm was 1.48 pounds, and for another slightly less than a pound. The last half of the past year has been unsatisfactory to many apiarists, for heavy rains, whenever there was a good bloom of guamá or the other principal bee flowers, washed out most of the nectar, and the bees have been able to make little more than half the usual amount of honey.

REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The general character of the work during the past year has been along lines similar to those of the preceding year, though with somewhat more attention to forage-crop production. A large part of the time was necessarily spent in work of routine character which is augmented at certain seasons by unfavorable conditions that affect the health and development of live stock in this locality.

During the year the station lost its entire herd of hogs, including 15 head of Berkshires, from an infectious disease. No definite knowledge was obtained as to the nature of the disease, as post-mortem examinations [1] made on various animals showed lesions of hog cholera, swine plague, and swine erysipelas.

HORSES.

The cooperative work in horse breeding between the station and various breeders has shown good results (Pl. IV, fig. 2). Of the progeny resulting from the American saddle-bred stallion during this time there are 26 from last year's crop and 16 in this year's crop. In all cases there is evident a remarkable prepotency of the sire. In color all his progeny is either black or bay. The yearlings are around 13½ to 14 hands, possess a good carriage, and when well filled out will make a nice type of horse. There are 22 colts, all in this year's crop, sired by the 2 thoroughbred stallions, 15 by the bay and 7 by the chestnut. The value of an occasional cross with thoroughbred blood is well shown in these colts. They are large, deep chested, and well muscled, and possess well-shaped legs and feet, with hard bone. With the type of mares available here as foundation stock it will probably prove safer to obtain size by making the first cross with thoroughbred blood, as the native horses have similar ancestral lines, and then proceed with any other blood necessary to obtain the object desired in conformation and action.

During the last year a number of standard-bred trotters (three mares and three stallions) have also been introduced here, and their hardiness to resist local conditions so far have won them much favor. One of the stallions has sired 27 colts in this year's crop. They are a

[1] The post-mortem examinations were made by Dr. Clark Hartman, veterinarian of the sanitation department of the island.

promising lot of young animals, but conclusions regarding their comparative value can not be drawn at present, as results in such work are necessarily slow. Some Morgan stallions have also been brought in during the past few years, but no record of their service has been obtained by this station as yet. A registered Morgan colt, Edmunds (Am. Morgan Register No. 6581), by General Gates No. 666, was obtained by the station through transfer from the Bureau of Animal Industry, and a 3-year-old American saddle-bred stallion (Black Badger No. 4213) was purchased in San Antonio, Tex. Both of these animals are good individuals with good ancestral lines of their respective breeds, and should contribute considerable benefit to the horse-breeding industry of the island.

CATTLE.

The cooperative work between the station and some of the cattle breeders on the south side of the island in producing a more useful work ox, as mentioned in the last report, is now in its second year of progress. The bulls used in this work, as previously stated, are cross-bred Zebu with Shorthorn and Zebu with Hereford. Two crops of calves have been sired. Of the first, or 1911, there are between 100 and 125 calves, and of the 1912 crop there are 132 calves by these bulls and from native cows.

Measured by standards of comparison there is little doubt as to the value of this cross. One lot of 62 of these calves, dropped about a year ago, now weigh between 600 and 700 pounds each, while calves in the same herd and of the same age, but by native bulls, weigh around 400 pounds each. There exists among breeders here a strong color prejudice in favor of the red. The calves from this cross present a great variety of color and color mixtures, which militates somewhat against the favor they justly deserve for their other good qualities.

The progress of developing a station dairy herd is going forward slowly. The half-bred Shorthorn heifers which are of breeding age are bred to Shorthorn bulls, and the Guernsey bull is used for crossing with native cows. The station now has five half-bred Shorthorn cows and heifers on native foundation and one three-quarters bred Shorthorn on native foundation. Some of the half-bred animals keep free from ticks, while some carry a considerable number when exposed to infestation, but in all cases under observation so far those having a long coat of hair carry a large number of ticks, and those with short smooth coats are free from ticks.

Unfortunately, nearly all the calves which have been sired by the Guernsey bull so far were males, and were therefore sold to the butcher. The service of these bulls has been offered to planters in

the neighborhood, and will, no doubt, be of benefit. Thirty-seven cows have thus far been brought to the station and bred to the Guernsey, 11 to the Jersey, and 4 to the Shorthorn bull.

DAIRYING.

The general agitation for pure wholesome milk has made itself felt on the island during the past year. The first step in this direction is retailing milk in a standard bottle with caps. Evidence of a desire for better milk is given by the strong demand for milk of the Ponce Sanitary Milk Co. and the milk sold by the station, both of which retail at from 2 to 6 cents higher per quart than milk from other sources, depending on the locality and season.

Owing to the excessively high price of milk and dairy products it is possible here to make a small margin of profit on cows that would be milked at a loss in the States. This no doubt accounts partly for the continuation of lax dairy methods, among which the partial milking of the cow with a calf is foremost. As native cows are of a rather nervous temperament it seems, in most cases, impossible to milk them without starting the milk flow with a calf if they have become accustomed to that method. This practice not only shortens the period of lactation, but the cows give less milk daily under this method than when milked without the calf. It is not uncommon that calves will refuse to suck the cow after 6 months of age, in which case the cow goes dry. A similar bad effect results from the custom, which is not uncommon, of milking only once a day.

The station dairy during the past year consisted of six cows. Three of these were broken to the native method of milking and three were milked without being started by the calf. Of the cows that had to be milked with calf to start the milk, one, a half Hereford half native, and the other two, which were pure native, gave 5 quarts when in full flow. The lactation period of these cows was, respectively, seven and a half and eight months. As the period of lactation advanced a decrease in quantity was shown in the pail, while a relatively larger proportion was consumed by the calf. The maximum amount obtained from any one of these cows was not over 1,800 pounds per year. Of the cows milked without a calf, one, a half Shorthorn half native, completed five months of her lactation period with nearly 2,000 pounds. A pure-bred native cow which has just calved gives 21 pounds daily, and a pure-bred Jersey has just completed a lactation period with 3,978 pounds. Near cities, where good milk sells at 10 cents or over, it is a losing proposition to conduct a dairy in which cows have to be milked partially by calves. At these prices of milk the calf costs approximately 25 cents a day, or in the

neighborhood of $60 at the end of an eight-months' lactation. As such calves can be purchased at that age for $20 or less there is a clear loss of at least $40 per cow.

As the station has had no laboratory in which to conduct investigations on the composition of milk, no tests have been made here; but an inspection of the records of the Ponce Sanitary Milk Co. showed that native cows yield milk which is as rich in butter fat as average dairies in the North. Some herds tested almost 6 per cent during March, one herd of over 50 cows tested over 6 per cent, and none at that time tested much below 4 per cent. As the patrons are paid by test, these data should be very reliable.

POULTRY.

The demand for poultry and eggs for breeding purposes is very brisk during the more favorable hatching season, from the beginning of December to about the 1st of April or May, depending on the weather conditions. There was a decrease in the sale of both fowls and eggs from previous years, due probably to the increase in number of private breeders who are engaged in this business. One trio of White Orpingtons was added to the flock during the year.

Some modern poultry plants have been established in the vicinity of San Juan. The results obtained at these farms warrant the statement that poultry can be grown as well here as in the North, and, further, that the losses need not be greater if the fowls are properly handled. The use of the hot-air brooder has no doubt contributed largely to the success of these enterprises, since by means of it chicks are forced through the first six or eight weeks much more rapidly than would otherwise be possible. The hot-air brooder gives an even temperature which, connected with the proper kind of food and sanitary conditions, brings these chicks to a larger size and makes them hardier, stronger, and better feathered at the end of this time, while chicks grown without the brooders are usually smaller, weaker, half-naked, and therefore much more subject to disease, especially sorehead and catarrh.

A number of remedies have been tried at the station for sorehead, such as carbolic acid, tincture of iodin, copper sulphate, potassium permanganate, creolin, and corrosive sublimate, but no results of value have been obtained when applied in very dilute solutions, as usually prescribed. The only decided success has resulted from undiluted creolin very carefully applied on the scabs with a feather and then washed with water after the scab is dry. This seemes very severe treatment, but no injury resulted from its use, and birds so treated were saved, whereas others in equally advanced stages treated with tincture of iodin and carbolic acid died.

FORAGE CROPS.

The introduction of a larger variety of forage crops is a very important factor in the live-stock development of the island. The introductions tried up to the present time consist of corn, sorghum, both saccharine and nonsaccharine, grasses, and legumes. Of the 20 varieties of corn, 12 have been obtained from Mexico, 2 from Brazil, and 6 from the States. Unfortunately, they were mostly destroyed by rats, some either before or after sprouting and the rest when the seed had formed but was still too immature to harvest. Up to the present time about 24 or more varieties of sorghum have been tried. Of these, 16 are of African origin furnished by the Bureau of Plant Industry, 1, commonly known as Guinea corn, was obtained from Barbados, 2 are from Mexico, 2 from Cuba, and the rest from the States. Of the African varieties only one has been preserved (B. P. I. No. 25341), being the most promising. It matures in 100 days under favorable conditions. The forage from a plat of this weighed 30 tons per acre. It has a thick stock, dense leaf development, dense seed head, and a peculiar sweet aroma. Cattle seemed to like it quite well. The Barbados variety, described in the last report, has given a very heavy crop again this year. The Cuban and Mexican varieties were destroyed by rats. The varieties from the States were planted during the dry weather and had therefore a poor start. Jerusalem corn yielded only 3 tons per acre. A plat of Improved Evergreen broom corn yielded somewhat less. Early Orange sorghum produced 11 tons per acre. Of these only the latter seems worthy of further trial. A small plat of teosinte has also been planted but has not come in seed yet.

A plat of Golden Tankard mangels was planted this year, but owing to a low percentage of viability only a few seed sprouted. The few roots that grew to maturity were very small, not more than one-quarter the size they naturally attain. Some white turnips and pumpkins have been grown successfully in the past. Native root crops, such as yams and yautias, have been successfully grown at the station,[1] but their culture for stock is of questionable value, owing to their starchy composition and their slowness in maturing. A few plats of rape were grown and fed to sheep. This should make a valuable feed when grown in small patches for sheep, goats, and pigs.

A few new grasses, *Paspalum dilatatum*, and Rhodes grass, were reported on last year. Nearly two years' trial shows that both will do well in lowland. Rhodes grass has held its own against malojilla whereas Paspalum is being partly crowded out by it. On high lands, in clay soils of poor mechanical condition, Rhodes grass was killed out by drought while Paspalum still retains a hold. A considerable

[1] See Report of Horticulturist, p. 26.

number of samples of these two grasses have been sent out over the island and they will therefore get trials under the varying conditions of soil and moisture.

During the year brown teff (*Eragrostis abysinica*) and molasses grass (*Melinis minutiflora*) were added. The former is a sort of wire grass which grows very rapidly, produces an abundance of seed, but does not grow very high or produce much leaf. Molasses grass propagates itself from runners the same as malojilla. In lowlands it grows much thicker with a heavier leaf development than malojilla. It has a very strong aroma, which probably has given it its name. It is the most productive grass tried here so far on lowland. None has yet been fed, but in Brazil, its habitat, it is given first place among grasses.

Pearl millet has made a splendid growth here, producing over 14 tons of forage per acre. Hairy vetch (*Vicia villosa*), which was given a trial, proved a failure, being of too delicate growth to contend with malojilla and the more common weeds.

Alfalfa, sweet clover, and crimson clover were also tried out during the year. Notwithstanding the extremely wet weather, the alfalfa has made good growth on lowland soils limed at the rate of 1,500 pounds per acre. Unlimed plats made a good start, but died out within six months. The limed plats have grown to about 2 feet in height. The first crop, about three months after seeding, yielded at the rate of 4 tons. After this was cut it was again limed at the rate of 1,200 pounds per acre, and the next cutting, made in three months, yielded at the rate of 6 tons per acre. Crimson clover sowed at the same time made not over 3 inches growth and died out within four months after seeding. Sweet clover was not given a fair trial, as the seed was applied too thin, but the indications are that it is worth the effort of further trials.

Among other legumes is a Stizolobium bean which has produced an immense crop of fodder. It grows in long vines 20 to 30 feet long, produces an abundance of leaves, but is very slow to mature seed. Plats of cowpeas, sword beans, and soy beans have also been planted this year with similar results as before. The seed harvested from half a plat of cowpeas (New Era) weighed 45 pounds, or at the rate of about 1,800 pounds (30 bushels) per acre. Sword beans also grow well, but soy beans have proved a failure in two attempts to grow them.

A lack of analyses of fodder crops grown in Porto Rico somewhat hinders obtaining a true estimate of their nutritive value.

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